

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
6 December 2007 (06.12.2007)

PCT

(10) International Publication Number
WO 2007/140218 A2

(51) International Patent Classification:
A47L 5/38 (2006.01)

(21) International Application Number:
PCT/US2007/069575

(22) International Filing Date: 23 May 2007 (23.05.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/420,194 24 May 2006 (24.05.2006) US

(71) Applicant and

(72) Inventor: JUNELL, Corey [US/US]; 2609 Country Road
134, Kaufman, TX 75142 (US).

(74) Agent: CARSTENS, David, W.; Carstens & Cahoon,
LLP, P.O. Box 802334, Dallas, TX 75380 (US).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,

AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH,
CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES,
FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN,
IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR,
LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX,
MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO,
RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM,
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,
ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,
FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL,
PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM,
GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— without international search report and to be republished
upon receipt of that report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.



WO 2007/140218 A2

(54) Title: DOOR THRESHOLD VACUUM

(57) Abstract: An apparatus for automatically cleaning dirt and debris from a pedestrian's footwear. The apparatus can be an integral portion of the entryway door's threshold or else can be made portable. The pedestrian steps upon a removable tray and activates a vacuum source. The vacuum source pulls the dirt and debris from the pedestrian's footwear through a multitude of openings in the removable tray. The dirt and debris is captured within the tray (large particles) and debris collection container (smaller particles) for later disposal. The apparatus cleans the welts and also provides a means for drying wet footwear. The apparatus can be either AC or DC powered and can be automated to only operate when a pedestrian is standing upon the tray, can operate continuously, or can be manually switched on and off.

DOOR THRESHOLD VACUUM

CROSS-REFERENCE TO RELATED APPLICATIONS

Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

THE NAMES OF THE PARTIES TO A JOINT RESEARCH AGREEMENT

Not Applicable

INCORPORATION-BY-REFERENCE OF MATERIAL SUBMITTED ON A COMPACT
DISC

Not Applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates generally to a novel vacuum system, and more specifically, to an apparatus for cleaning dust, dirt, and debris from the footwear of a pedestrian entering a building.

2. Description of Related Art

[0002] A variety of proposals have previously been made to control the tracking of dust, dirt, and debris caused by the footwear of a pedestrian entering a building. The most basic means is a doormat upon which the pedestrian wipes his or her shoes prior to entering. However, even

when the shoes are relatively clean the doormat does little to remove and retain any debris and often contaminates the shoes of other pedestrians who may follow.

[0003] U.S. Patent number 4,024,599 (*Gamboa*) discloses an apparatus for cleaning the bottom of a wearer's shoes. The apparatus in *Gamboa*, a "Shoe Cleaning Machine" as illustrated in FIG. 1A, is a free-standing machine that has a platform upon which the wearer stands. Once activated, the machine physically scrubs debris from the wearer's shoes with bristles attached to a motorized belt while an integral fan carries the debris to a removable bag located in the housing. One of the drawbacks to *Gamboa* is that the machine is physically impractical for use in other than industrial settings. In addition, *Gamboa* utilizes a motorized belt with bristles that physically scrub a wearer's shoes, resulting in increased wear, maintenance and operating expense.

[0004] U.S. Patent number 4,027,355 (*Mead et al.*) discloses a pneumatic cleaning mat that provides positive cleaning action of a pedestrian's footwear. The mat in *Mead et al.* utilizes a pressurized tank of air that discharges through poppet valves located on the top surface of the mat when a pedestrian steps upon the mat. Thus, attached debris is blown away from the footwear. Because *Mead et al.* requires compressed air, its operation would likely result in debris being blown unpredictably about which could result in physical injury to a user. Also, the discharge of air would likely be noisy, making the device impractical for other than industrial settings. Maintenance of the poppet valves would likely be financially and physically burdensome, resulting in significant operating expense.

[0005] U.S. Patent number 4,551,879 (*Ray*) discloses an entrance dust arrester that vacuums the area directly under a door as it swings on its hinges. The vacuum in *Ray*, as illustrated in FIG. 4, is integral with the door, with the suction on the bottom of the door positioned such that it can vacuum the mat lying beneath. Thus, an individual who walks through the door and steps on the mat will leave debris on the mat which will be vacuumed upon closing the door. *Ray* requires a user to physically scrub their footwear on the mat beneath the door and then rely on the door to vacuum any debris away. Thus, if the user swings the door too quickly, the vacuum may be ineffective in cleaning the mat and the next individual to enter may end up tracking the debris that should have been previously captured. Also, this device requires extensive

modification to an existing door which would increase installation, maintenance, and operating costs.

[0006] U.S. Patent number 6,067,688 (*West*) discloses a shoe cleaning device for scrubbing and vacuuming shoes. The device of *West*, as illustrated by FIG. 3, is either portable or else mounted in the floor of an entrance. Individuals entering would step on the device and wire bristles would physically scrub the individual's shoes. Debris would be carried away from the bristles by a powerful squirrel cage fan mounted directly beneath the top surface of the device. *West* requires significant space to house the internal components as disclosed. Thus, the physical size of the *West* device would make it impractical for use in other than industrial settings. Also, *West* requires both a squirrel cage fan and a vacuum source which increases expense and maintenance costs, further making it impractical for use in other than industrial settings.

[0007] Other prior proposals include footwear cleaning means utilized in semiconductor fabrication clean rooms such as the Sole Cleaner™ Automatic Contamination-Control Mat (illustrated by FIG. 2) and the Motorized Shoe Cleaner (illustrated by FIG. 1B), both offered by Terra Universal, Inc. The Sole Cleaner™ is similar to other clean room contamination-control offerings that utilize a mat with a sticky surface that physically adheres to debris on footwear. Prior to entering a clean room, the individual would walk across the sticky surface of the mat to remove debris from the bottom of his or her shoes. After a fixed number of uses, the sticky-mat surface must be changed. The Motorized Shoe Cleaner operates much the same as *Gamboa* in that it is a free-standing machine upon which an individual would step prior to entering a clean room. The Motorized Shoe Cleaner would then be activated to physically scrub debris from the individual's shoes and vacuum the debris away. Because of the increased number of components that wear and need to be replaced frequently, both of these devices require significant maintenance and operating expenditures that make them impractical for use in other than industrial settings.

[0008] Nothing in the prior art addresses the problems associated with providing a footwear cleaning means that is practical for use in an other than industrial setting. Therefore, a need exists for an improved footwear cleaning device that is suitable for use in residential, commercial, and industrial situations. Further, a need exists for an improved footwear cleaning

device that is compact, quiet, and aesthetically attractive. And further, a need exists for an improved footwear cleaning device that requires relatively little maintenance and is inexpensive to operate. The present invention fills these needs and other needs as detailed more fully below.

BRIEF SUMMARY OF THE INVENTION

[0009] The present invention is directed to a footwear cleaning device or apparatus that can be used in residential, commercial, or even industrial settings. Prior art designs tend to require extensive modification to existing entryways or require large housings if used in a portable embodiment. Because of this, they tend to be impractical for use in other than industrial settings. The present invention is designed to overcome this problem and others by reducing the size, component count, and expense related to operation and maintenance.

[0010] Accordingly, it is one general object of the invention to provide a footwear cleaning device that can be easily installed in the threshold area of an existing doorway, or else made portable for use in a variety of situations.

[0011] It is another general object of the invention to provide a footwear cleaning device that minimizes the problem of excessive maintenance and expense associated with prior art devices by reducing the number of moving parts and eliminating excessive components that are designed to wear and require frequent replacement.

[0012] It is another general object of the invention is to provide a footwear cleaning device that efficiently cleans both the bottom and the welt of a shoe, and also dries the shoe if wet.

[0013] It is another general object of the invention is to provide a footwear cleaning device that is more aesthetically pleasing.

[0014] Yet another general object of the invention is to provide a footwear cleaning device that can be powered from either an AC or DC power source, thus lending to its flexibility and portability.

[0015] The invention accordingly comprises the features described more fully below, and the scope of the invention will be indicated in the claims. Further objects of the present invention will become apparent in the following detailed description read in light of the drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

[0016] The novel features characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will be best understood by reference to the following detailed description of illustrative embodiments when read in conjunction with the accompanying drawings, wherein:

FIG. 1A illustrates a perspective view of an embodiment of a prior art design for a motorized shoe cleaning machine;

FIG. 1B shows an embodiment of the prior art design of Fig. 1A being used by a clean room technician to clean her footwear prior to entering a workspace;

FIG. 2 shows an embodiment of a prior art design for a sticky-mat being used by a clean room technician to clean her footwear prior to entering a workspace;

FIG. 3 illustrates a frontal view of an embodiment of a prior art design for a shoe scrubbing and vacuuming device that utilizes a squirrel cage fan for debris removal in conjunction with a vacuum source;

FIG. 4 illustrates a perspective view of a prior art design for an entrance dust arrestor device that vacuums the mat beneath the door whenever the door is opened or closed;

FIG. 5A illustrates a first embodiment of the present invention configured as an integral portion of a door threshold;

FIG. 5B illustrates a top down view of the first embodiment of FIG. 5A to further display the elements of the device;

FIG. 6 illustrates a top down view of a variation on the first embodiment of FIG. 5 wherein the vacuum source is supplied externally;

FIG. 7A illustrates a perspective view of a second embodiment of the present invention,

configured as a portable door threshold vacuum device for residential or light commercial use;

FIG. 7B illustrates a top down view of the second embodiment of FIG. 7A to further display the elements of the device;

FIG. 7C illustrates a side view of the second embodiment of FIG. 7A to further display the elements of the device; and

FIG. 8 illustrates a perspective view of a third embodiment of the present invention, configured as a portable door threshold vacuum device for commercial and industrial use.

[0017] Where used in the various figures of the drawing, the same reference numbers designate the same or similar parts. Furthermore, when the terms “top,” “bottom,” “first,” “second,” “upper,” “lower,” “height,” “width,” “length,” “end,” “side,” “horizontal,” “vertical,” and similar terms are used herein, it should be understood that these terms have reference only to the structure shown in the drawing and are utilized only to facilitate describing the invention.

[0018] All figures are drawn for ease of explanation of the basic teachings of the present invention only; the extensions of the figures with respect to number, position, relationship, and dimensions of the parts to form the preferred embodiment will be explained or will be within the skill of the art after the following teachings of the present invention have been read and understood.

Reference Numbers

- 500 door threshold vacuum
- 502 tray
- 504 vacuum source
- 506 debris collection container
- 508 vacuum source controller
- 510 power switch
- 512 activation sensor
- 514 power source
- 516 access panel
- 518 vacuum port cover
- 520 vacuum port
- 522 doorsill plate
- 524 vacuum air discharge port
- 526 shoe welt vacuum port
- 528 AC outlet

DETAILED DESCRIPTION OF THE INVENTION

[0019] Referring now to the provided drawings, similar reference numbers represent the equivalent component throughout the several views of the drawings.

[0020] **FIG. 5** illustrates a first embodiment of a door threshold vacuum **500** as it would appear when mounted as an integral part of a door threshold. **FIG. 5A** illustrates how the embodiment of the device might appear to a pedestrian as they approach the door. **FIG. 5B** illustrates a top-down view of the embodiment to provide further detail of its elements. When the pedestrian opens the door and steps upon the removable tray **502**, the door threshold vacuum **500** activates and pulls the dirt and debris from the bottom of the pedestrian's footwear. Thus, the dirt and debris are trapped within the apparatus, significantly reducing and possibly eliminating the amount of dirt and debris that is normally carried into a building upon the footwear of one who enters.

[0021] With reference to **Fig. 5**, the door threshold vacuum **500** apparatus illustrated in this first embodiment is an integral portion of the threshold of an entryway door. Because it is integral, the door threshold vacuum **500** includes a doorsill plate **522** that can be adjusted to maintain proper contact with the weather stripping typically present on the lower edge of an exterior door. On an interior door where there typically is no weather stripping, the doorsill plate **522** can be adjusted to prevent interference with the bottom of the door. Other embodiments may include a doorsill plate **522** that is fixed in order to reduce the number of components in manufacture.

[0022] The door threshold vacuum **500** includes a removable tray **502** upon which the pedestrian steps when entering the doorway. The tray **502** contains either a multitude of ridges or a raised tread pattern, with a multitude of openings through which the external air flows into the vacuum source **504**. The vacuum source **504** can be any device, such as a fan or a vacuum pump, which creates a negative pressure differential that causes the flow of air from the multitude of openings in the tray **502** toward the vacuum source **504**. While the vacuum source

504 is operating, the dirt and debris on the pedestrian's footwear is pulled into the bottom of the tray **502**. Optional slight movement of the pedestrian's footwear while in contact with the tray **502** will also serve to dislodge dirt and debris trapped on the soles of the footwear. Most of the heavier dirt and debris is trapped within the bottom void spaces of the tray while the lighter dirt and debris is pulled through the multitude of openings and into the debris collection container **506** where it is trapped for later removal.

[0023] This first embodiment also includes a shoe welt vacuum port **526** that assists the pedestrian in cleaning the welts of the pedestrian's footwear. While the vacuum source **504** is energized, the air drawn through the shoe welt vacuum port **526** pulls the loose dirt and debris from the footwear's welt where it is trapped within the debris collection container **506**. The pedestrian is required to alternately move his or her welts in front of the shoe welt vacuum port **526** while the vacuum source **504** is operating. In addition, the discharge air of the vacuum source **504** exits from the vacuum air discharge port **524** and can be used to dry the pedestrian's footwear if wet.

[0024] In a residential or light commercial setting where operating noise may be an issue, the door threshold vacuum **500** can easily be quieted. The housing containing the vacuum source **504** may be internally lined with a sound-deadening type of insulation such as: closed cell foam, polyurethane foam, melamine foam, cotton fiber, or glass fiber.

[0025] The first embodiment as illustrated in **FIG. 5** utilizes an integral vacuum source **504** that is electrically powered. The power source **514** can be either AC (standard alternating current electrical service from an electrical utility provider) or DC (direct current such as from a battery) depending upon the requirements of the motor of the vacuum source **504**. In the AC version, the power source could be wired into the AC electrical service of the building in which the door threshold vacuum **500** is installed. An additional AC outlet **528** can also be added to the access panel **516** to allow external AC devices to be plugged into the apparatus. In the DC version, the power source **514** would likely include a rechargeable battery and some type of

recharging circuitry that could also be wired into the AC electrical service of the building in which the door threshold vacuum **500** is installed.

[0026] The first embodiment as illustrated in **FIG. 5** utilizes a power switch **510** that allows operation of the door threshold vacuum **500**. The power switch **510** can have two operating positions (on/off) or more, such as when an additional sensor is used to provide for automated use. A multiple position switch allows the apparatus to be switched completely off (such as for maintenance), completely on (such as for continuous operation), or placed in some intermediate position (such as for automatic operation).

[0027] This embodiment also employs an activation sensor **512** that detects when the door is operated, thus signaling the vacuum source controller **508** to energize the vacuum source **504** in preparation for capturing the dirt and debris on a pedestrian's footwear. The activation sensor **512** could be a mechanical limit switch, a photodetector, or some other type of device that can transform the stimulus of the door opening into a signal that allows the vacuum source controller **508** to operate. In another embodiment the activation sensor **512** could be triggered by the weight of the pedestrian stepping upon the tray **502**. In still further embodiments, such as one designed for continuous operation, the activation sensor **512** may not be utilized and the vacuum source controller **508** may be controlled directly by the power switch **510**.

[0028] This first embodiment of **FIG. 5** generally requires very little maintenance. Dirt and debris from the pedestrian's footwear that is captured in the tray **502** is disposed of by removing the tray and either inverting it, vacuuming it with a household vacuum, or using a compressed air source to blow it clean. The debris collection container **506** is removed and cleaned by opening the access panel **516**. Likewise, the vacuum source **504**, vacuum source controller **508**, and power source **514** can be accessed by opening the access panel **516**.

[0029] The first embodiment of **FIG. 5** is a universal design that allows the housing that

contains the vacuum source **504** and its additional circuitry to be positioned on either the right or left sides of the tray **502**. This will allow the door threshold vacuum **500** to be used with entryway doors regardless of which side of the door the hinges are located. Ideally, the housing will be located on the side opposite that of the door hinges, although this is not absolutely necessary. Thus, the door threshold vacuum **500** has a vacuum port **520** on either side; the housing is attached to one vacuum port **520** while the other unused vacuum port **520** is blocked with a vacuum port cover **518**.

[0030] **FIG. 6** illustrates a variation on the first embodiment that utilizes an external vacuum source. In this variation, the entire housing that contains the vacuum source **504** and its additional circuitry is removed and the vacuum port **520** which was being utilized by the vacuum source **504** is blocked with a vacuum port cover **518**. The external vacuum source is then coupled with the other vacuum port **520**. This configuration can be used in homes or businesses that have, for instance, either a central vacuum system or some other vacuum source that is remotely located. As with the interchangeable housing, the external vacuum source may be connected to either vacuum port **520** depending upon the demands of the configuration.

[0031] **FIG. 7** illustrates a second embodiment of the present invention, configured as a portable door threshold vacuum **500** device for residential or light commercial use. This second embodiment is designed to be more compact and low in profile so as to enhance its portability and aesthetic qualities. The access panel **516** covers the power source **514**, debris collection container **506**, and vacuum source **504**. The power source **514** in this embodiment is ideally DC (such as a rechargeable battery), but can also be AC. In the AC configuration, it can either be plugged into a wall outlet or directly wired into the building's electrical supply. If AC powered, an additional AC outlet **528** is provided to power external devices.

[0032] The second embodiment of **FIG. 7** utilizes a power switch **510** that can have either two positions (on/off) or more, such as when an additional sensor is used to provide for automated use. For instance, an activation sensor **512** may be incorporated to detect when a

pedestrian is standing on the tray **502**. The activation sensor **512** could be a photodetector, or some other type of device that can transform the stimulus of the pedestrian stepping onto the tray **502** into a signal that allows the vacuum source controller **508** to operate. In another embodiment the activation sensor **512** could be triggered by the weight of the pedestrian stepping upon the tray **502**. In still further embodiments, such as one designed for continuous operation, the activation sensor **512** may not be utilized and the vacuum source controller **508** may be controlled directly by the power switch **510**.

[0033] **FIG. 8** illustrates a third embodiment of the present invention, configured as a portable door threshold vacuum device for commercial and industrial use. In this embodiment, it is likely that size will not be as much of an issue. Therefore, the internal components (power source **514**, vacuum source controller **508**, and vacuum source **504**) may be of heavier grade for more strenuous and potentially continuous operation. Operation and maintenance of this embodiment would be similar to the lighter duty configuration as described above and illustrated in **FIG. 7**.

[0034] In view of the foregoing, the door threshold vacuum **500** serves needs not met by prior art devices. It can be used in residential, commercial, and even industrial settings to efficiently remove dirt and debris from a pedestrian's footwear. In addition, it does not require extensive modification to existing entryways in its permanent installation embodiment or else require large housings in a portable embodiment. Because of this, it is more practical for use in a wider variety of settings. Finally, its reduced size, component count, and expense related to operation and maintenance makes the proposed door threshold vacuum **500** a more efficient and cost effective means of capturing the dirt and debris from footwear so as to minimize wear and tear on the flooring of a building.

[0035] In addition to the use of a vacuum, the threshold vacuum device can also be outfitted with an electrostatic plate. It is accepted that dust is typically negatively charged. Therefore, an electrostatic plate could attract a portion of this dust or other negatively charged debris.

[0036] Further, the threshold vacuum device can include an ultra-violet light source to irradiate the user's shoes. The UV light kills a segment of the bacteria and viruses that are also present on the user's shoes. This is particularly important in view of concerns over virus pandemics such as the bird flu.

[0037] The terms and expressions employed herein have been used as terms of description and not of limitation. While specific embodiments of the invention have been disclosed, one of ordinary skill in the art will recognize that one can modify the dimensions and particulars of the embodiments without straying from the inventive concept. For example, the threshold vacuum, power, control circuitry, and housing could be completely mounted inside a wall such that no part of the device other than the tray upon which a user stands is visible. It will now be evident to those skilled in the art that there has been described herein an improved door threshold vacuum that provides significant improvements over existing shoe cleaning methods and devices.

CLAIMS

I claim:

1. An apparatus for cleaning footwear, said apparatus comprising:
 - a vacuum source;
 - a debris collection container, said debris collection container in communication with said vacuum source;
 - a first housing, said first housing having at least one first port in communication with said debris collection container;
 - a second port, said second port in communication with said vacuum source;
 - a tray with a plurality of openings, said tray being removably retained by said housing; said vacuum source causing air to flow in through the plurality of openings in said tray, said first port, said debris collection container, and out said second port.
 - a power source, said power source capable of powering said vacuum source;
 - a vacuum source controller, said vacuum source controller for controlling said vacuum source;
 - a switch, said switch controlling the operation of said vacuum source; and
 - a second housing, said second housing comprising said vacuum source, said vacuum source controller, said power source, and said debris collection container.

2. The apparatus of Claim 1 further comprising a third port with a plurality of openings, said third port in communication with said debris collection container; said vacuum source draws air in through said third port, said debris collection container, and out said second port.
3. The apparatus of Claim 1 wherein the air discharged from said second port is used to dry wet footwear.
4. The apparatus of Claim 1 further comprising an activation sensor, wherein said activation sensor communicates with and influences the operation of said vacuum source controller and is selected from the group consisting of a photodetector, a photocell, and a mechanical switch.
5. The apparatus of Claim 1 wherein said vacuum source is an external vacuum cleaner.
6. The apparatus of Claim 1 wherein said debris collection container utilizes a removable filter bag.
7. The apparatus of Claim 1 wherein said power source comprises a rechargeable DC battery.
8. The apparatus of Claim 1 wherein said power source utilizes AC power supplied by an electrical utility.
9. The apparatus of Claim 1 further comprising an external AC outlet.
10. The apparatus of Claim 1 further comprising two first ports, each of said first ports located on opposite sides of said first housing to allow said debris collection container to be in communication with either of two first ports, thus allowing said second housing to be located on either side of said first housing.

11. The apparatus of Claim 1 wherein said apparatus is portable.
12. The apparatus of Claim 1 wherein said apparatus is permanently mounted in the threshold of an entryway door.
13. The apparatus of Claim 12 further comprising an adjustable doorsill.
14. The apparatus of Claim 1 wherein said second housing is lined with sound-deadening insulation to reduce operating noise levels of said apparatus.
15. The apparatus of Claim 14 wherein said sound-deadening insulation is chosen from the group consisting of closed cell foam, polyurethane foam, melamine foam, cotton fiber, and glass fiber.

1/5

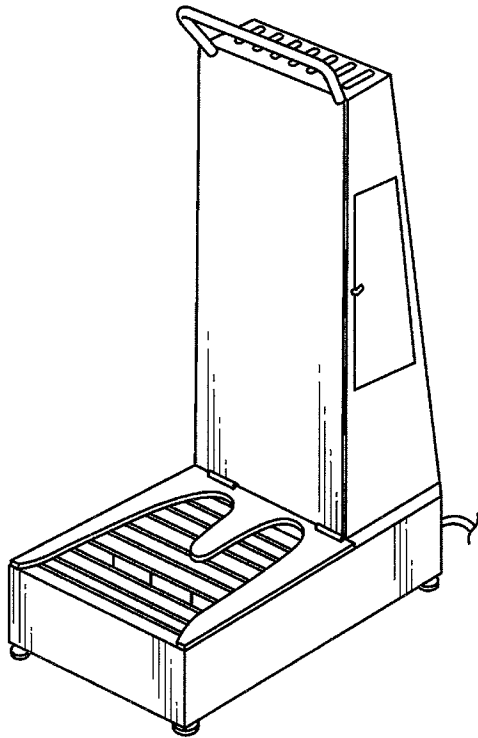


FIG. 1A
(Prior Art)

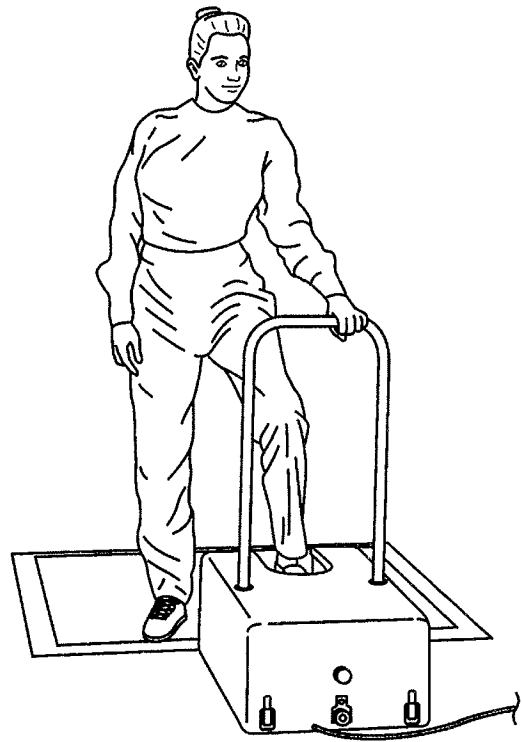


FIG. 1B
(Prior Art)

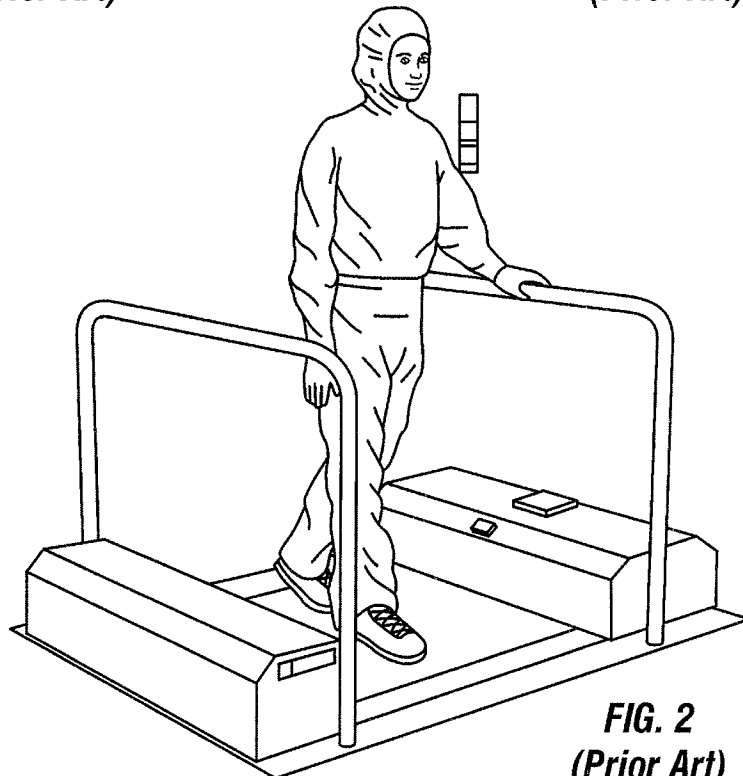


FIG. 2
(Prior Art)

2/5

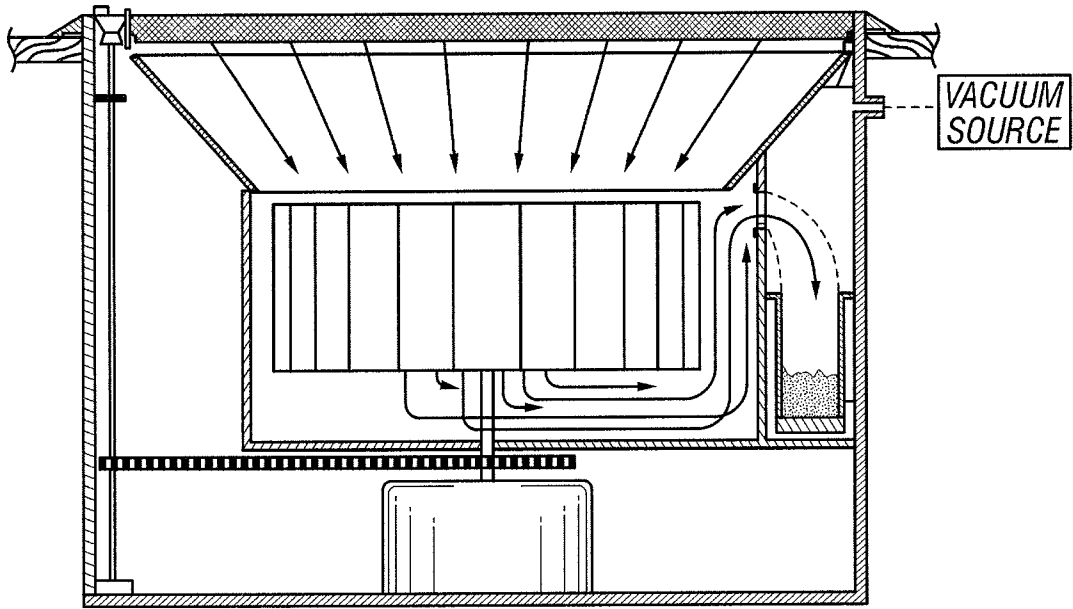


FIG. 3
(Prior Art)

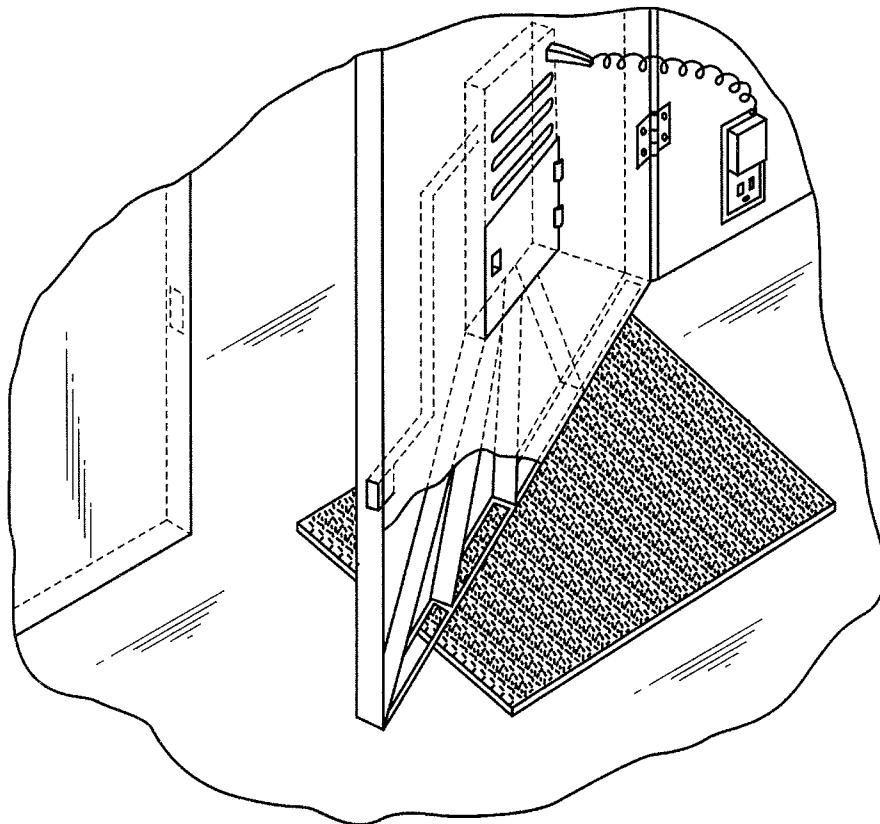
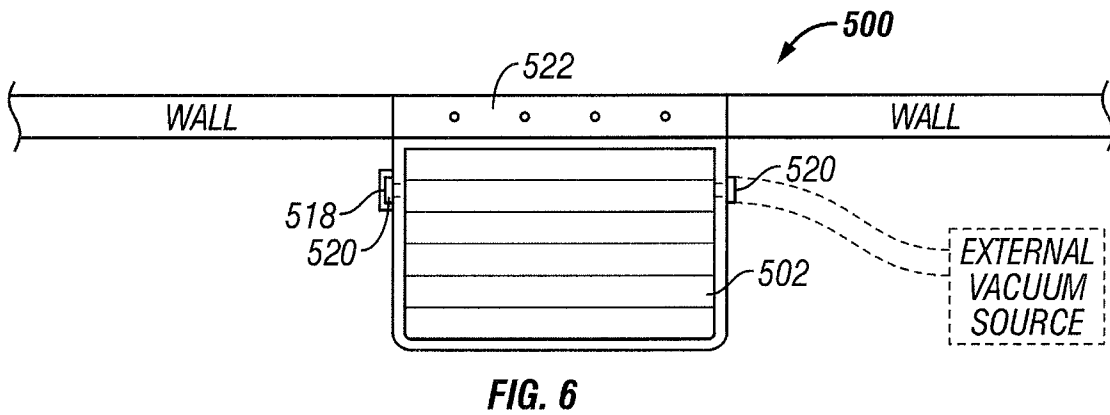
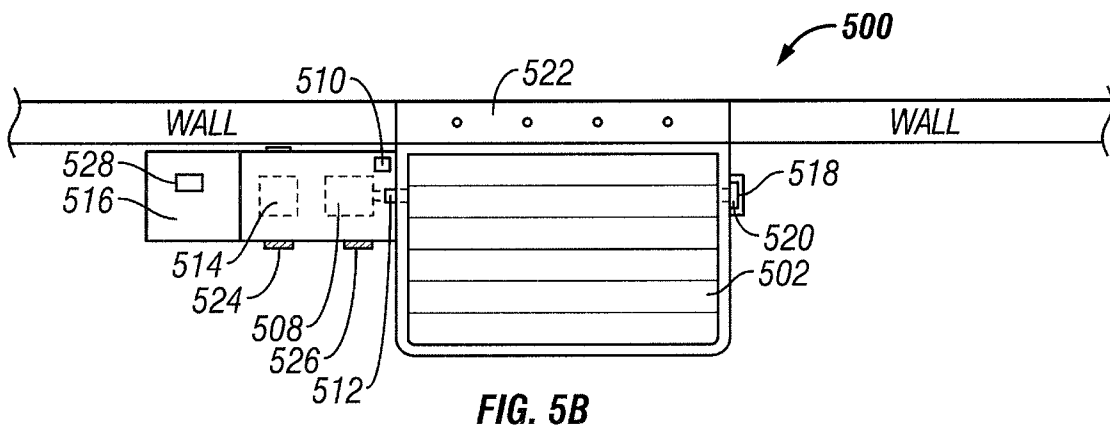
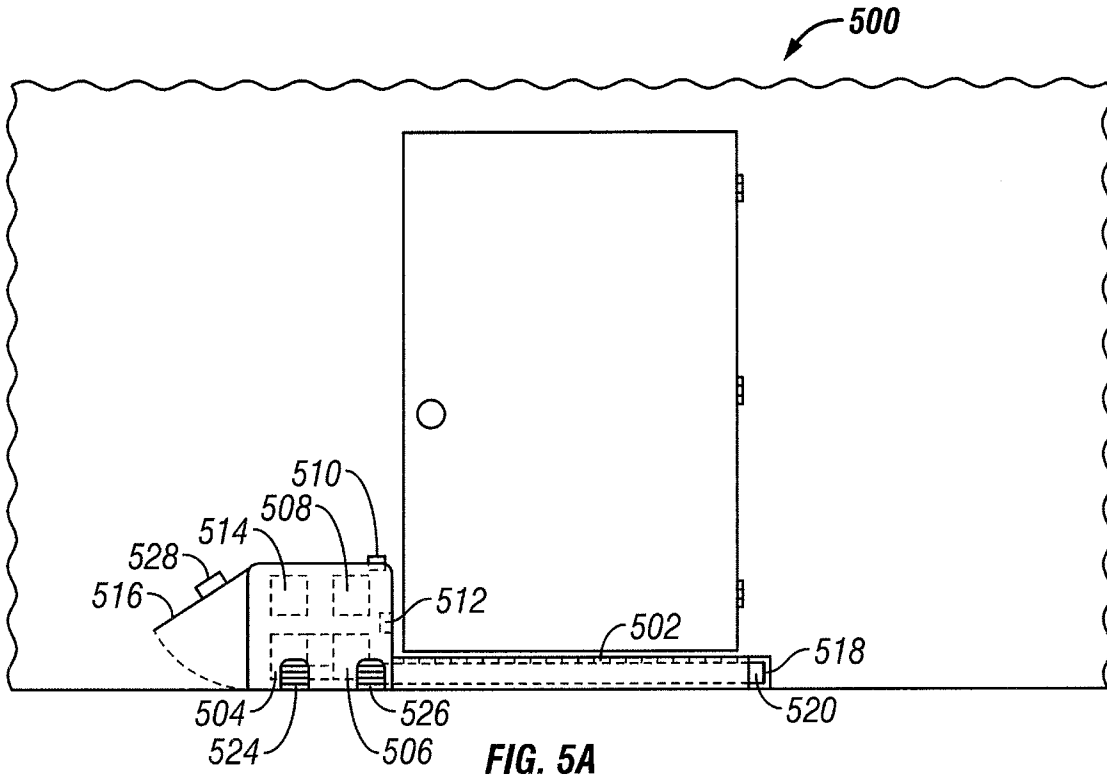


FIG. 4
(Prior Art)

3/5



4/5

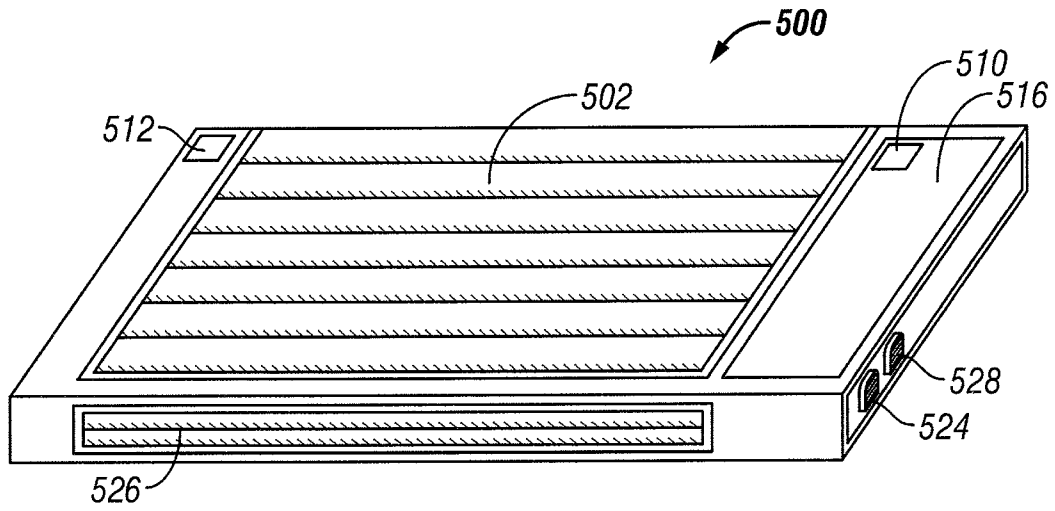


FIG. 7A

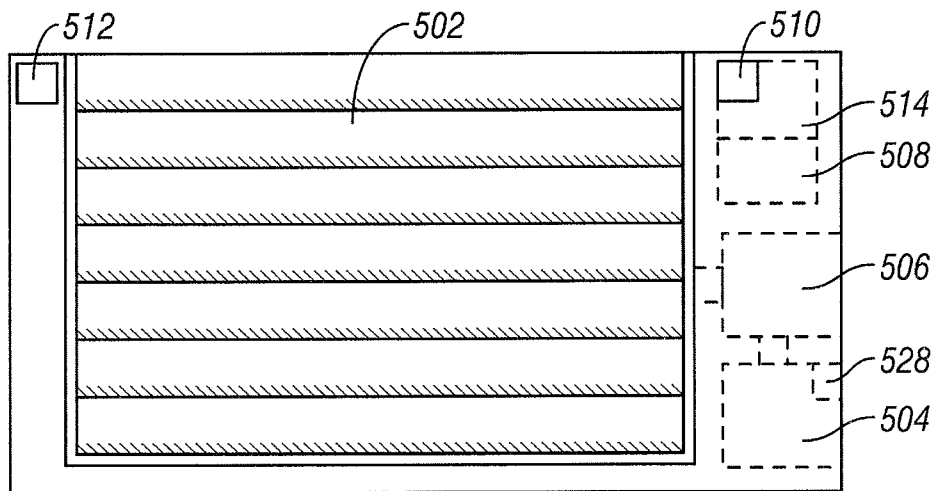


FIG. 7B

5/5

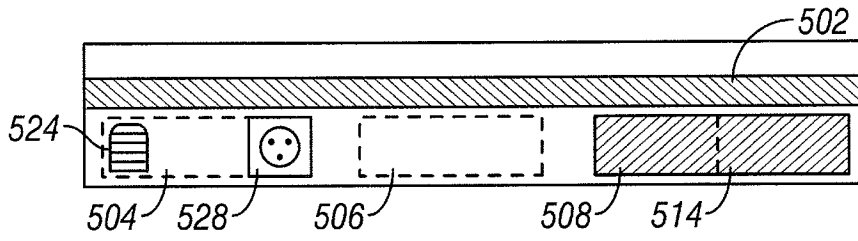


FIG. 7C

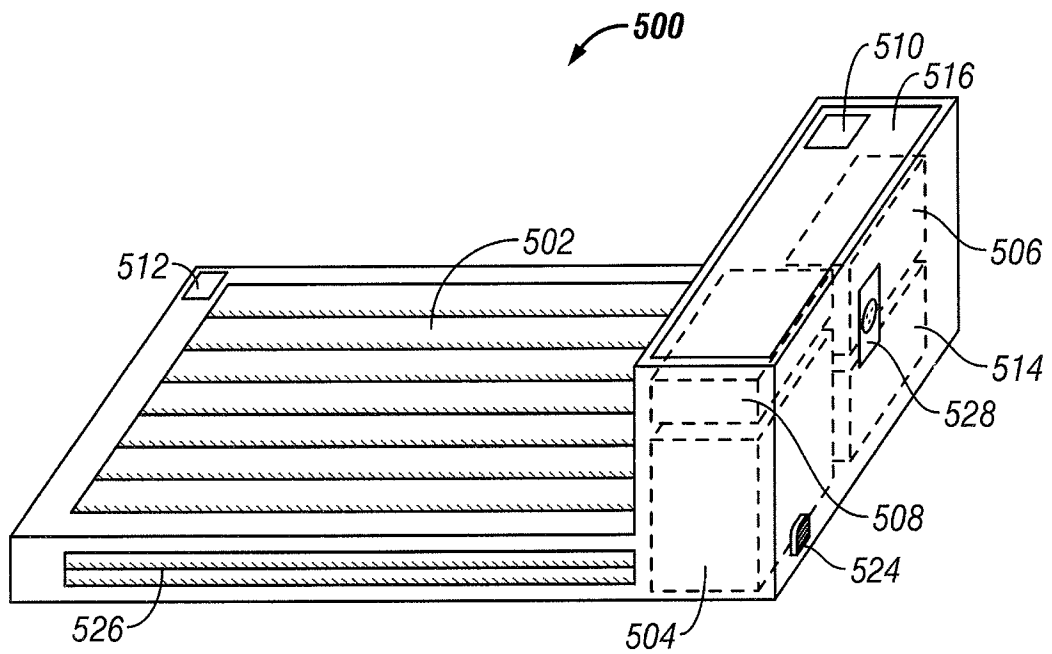


FIG. 8